BLUE ECONOMY
COOPERATIVE RESEARCH CENTRE

MARINE SPATIAL PLANNING FOR A BLUE ECONOMY IN AUSTRALIA

Identifying synergies and trade-offs between sectors in the Blue Economy Zone

MILESTONE REPORT

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Jackson Stockbridge & Caitlin D. Kuempel (Editors)

THE BLUE ECONOMY CRC

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CONTENTS

TABLES

FIGURES

1. Summary

Blue Economy sustainability goals aim to ensure the longevity of the economic, social, cultural, and environmental contributions of ocean ecosystems.

Australia aims to double the value of its blue economy by 2025 (National Marine Science Committee 2015), while reducing its greenhouse gas emissions by 2030 (Australian Government 2022). To achieve this, Australia has invested significantly into offshore renewable energy. However, Australia's oceans are crowded with uses, and ocean management is currently conducted using a sector-based approach, with little cross-industry integration.

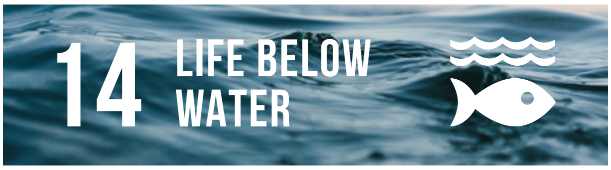
An integrated ocean planning and management strategy that incorporates multiple industries when balancing equitable ocean resources and space, whilst also considering environmental impacts, is needed for Australia to achieve its sustainable Blue Economy goals.

In this report, we discuss Australia's need to implement integrated ocean planning and management using a case study of the Bass Strait, a hotspot of Blue Economy activity and an area targeted for significant offshore wind development. We review the guidelines for current Environmental Impact Assessments for Victorian offshore wind farms and collate the impacted species data to demonstrate the need for an integrated management approach for Australia to retain its biodiversity. We then use existing spatial data to map industry overlap in Australia, with a more detailed focus on Bass Strait.

Our approach helps to identify synergies and trade-offs between sectors in Australia's Blue Economy Zone and represents progress in utilising spatial data to enhance decision-making across various industries. It aims to identify areas where combined socio-economic and environmental impacts from multiple industries are most likely to occur.

2. Background

The need to retain ocean ecosystem services and safeguard its biodiversity has led to the emergence of the "Blue Economy". The Blue Economy refers to "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems" (The World Bank 2017).



Multiple nations have endorsed the Blue Economy strategy by establishing goals to ensure ocean ecosystem services and sustainability into the future. For example, of the 17 United Nations sustainable development goals (UN 2012), Blue Economy sustainability (see SDG 14, "Life Below Water") was identified as the highest priority by government agencies and policy makers (Lee *et al.* 2020).

AUSTRALIA HAS OUTLINED ITS TARGET TO

DOUBLE THE VALUE

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The pursuit of these targets has prompted significant investment into the expansion of Blue Economy sectors, including the declaration of 33,000 km2 for offshore wind farm development (DCCEEW 2024). However, Australia's coastlines are already crowded with existing uses, such as offshore aquaculture, active shipping lanes, and conservation areas.

Additionally, 85% of its population reside within 50 km of the coast (Clark and Johnston 2017), and the ocean holds significant environmental, economic, social, and Indigenous significance (Richardson and Poloczanska 2009; Rist et al. 2019).

The Bass Strait is a hotspot of Blue Economy activities, including multiple protected areas, continuous shipping, and seafood production, as well as ecological and cultural significance, making it an important case study area.

The region serves as a crucial migratory pathway for vulnerable birds and whales, contributes economically through Tasmanian salmon aquaculture, and possesses cultural and social significance due to its tourism sector and heritage sites, such as the submerged land bridge that connects Tasmania with Victoria (Bowdler 2015).

OF THE 33,000 km²

DECLARED FOR WIND FARMS,

17,000 km²

ARE WITHIN BASS STRAIT, MEANING IT WILL BECOME INCREASINGLY CROWDED WITH OFFSHORE INDUSTRY USES IN THE FUTURE.

Operational expansion of sectors further offshore increases the likelihood of conflicts with current ocean stakeholders and threatens to introduce additional pressures to Australia's marine environment. As the number of overlapping environmental pressures increases, so too does the likelihood of synergistic environmental impacts (see April 2023 milestone report), where multiple pressures interact non-additively to affect ecosystem condition. As such, it is necessary to reassess the current approaches to manage ocean resources and ecosystem health if Australia is to achieve its Blue Economy goals. This report uses existing spatial data on Australian ocean uses to:

1. **Demonstrate the need for a management framework that integrates multiple industries and accounts for the full suite of cumulative impacts, using Environmental Impact Assessments (EIAs) for wind farm projects in Victoria as a case study.**
2. **Map and quantify instances of sector overlap within Australia's Exclusive Economic Zone (EEZ), showcasing the advantages of this process using a case study focused on Bass Strait.**
3. **Outline the need for a framework that can be used to identify trade-offs and synergies between industries and reduce the risk of project proponents incurring financial losses.**

3. Sector-based ocean management

Current frameworks for Australian ocean management are predominantly sector-based, whereby activities and threats are considered in isolation (Stephenson *et al.* 2019).

Sectoral planning often leads to temporal and spatial overlap of multiple uses, leading to inter-sector conflict and interactions. Industry conflict risks generating increased costs for developers and/or significant financial losses due to a project being relocated, necessary environmental management or mitigation measures, or delays and complications in the approvals process. Furthermore, industry interactions create risks for project developers and investors due to the uncertainty around accountability for environmental impacts (Douvere 2008). This not only increases the risk of heightened conflicts among industries but also adds complexity to managing the combined environmental impacts of multiple pressures (also known as 'cumulative impacts').

Cumulative impacts cause unpredictable changes in ecosystem condition and can generate social opposition to a project. Managing cumulative impacts across multiple projects and industries is particularly challenging, and few regions have successfully implemented EIA guidelines that account for the full suite of cumulative impacts (Griffiths *et al.* 2020; Willsteed *et al.* 2023). Cumulative impacts of multiple, cross-industry pressures threaten to degrade ecosystems beyond a threshold from which they cannot recover (May *et al.* 2008), resulting in a significant loss of Australian biodiversity and ecosystem services.

Therefore, by following a sector-based approach that does not account for industry interactions and the full suite of cumulative impacts, Australia is risking the environmental and socio-economic sustainability of its blue economy

4. Integrated ocean management

A framework that integrates multiple sectors to manage ocean resources and space allocation is necessary for Australia to achieve its Blue Economy goals sustainably.

A multi-sector management framework should follow an ecosystem-based approach to account for the full suite of cumulative impacts both within, and among multiple industries (*Fig. 1*).

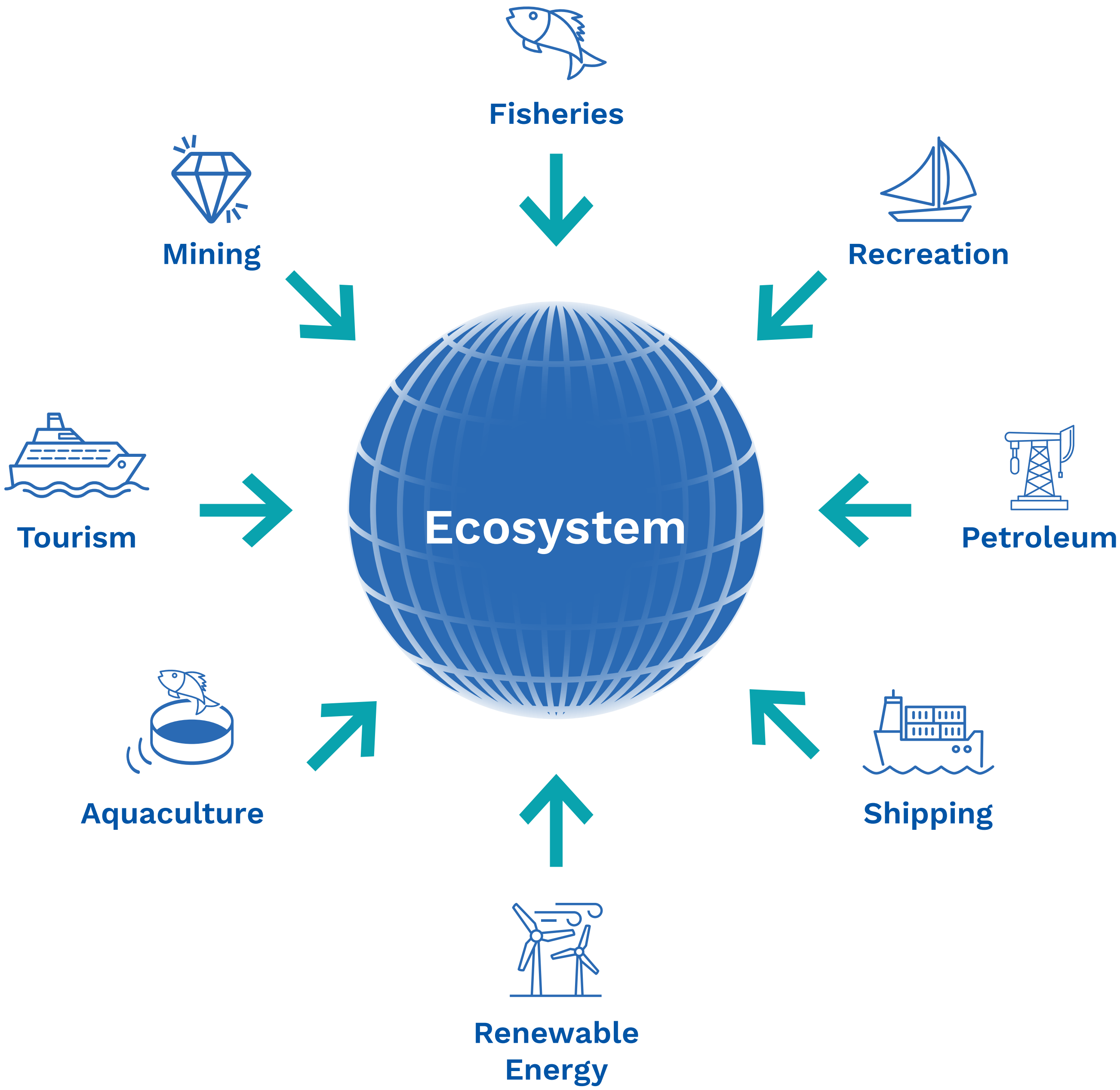
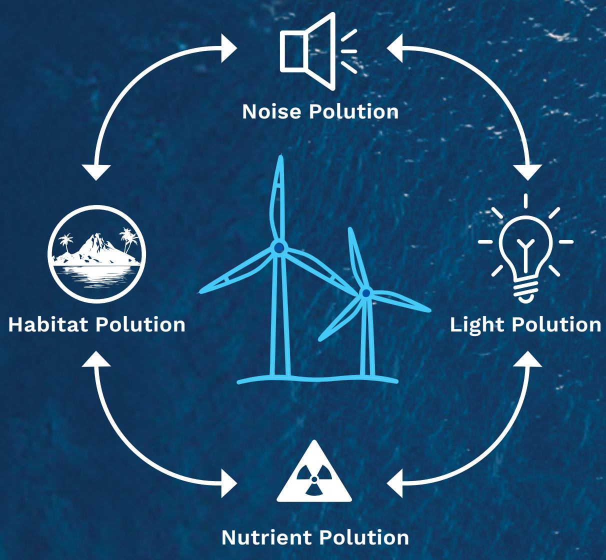
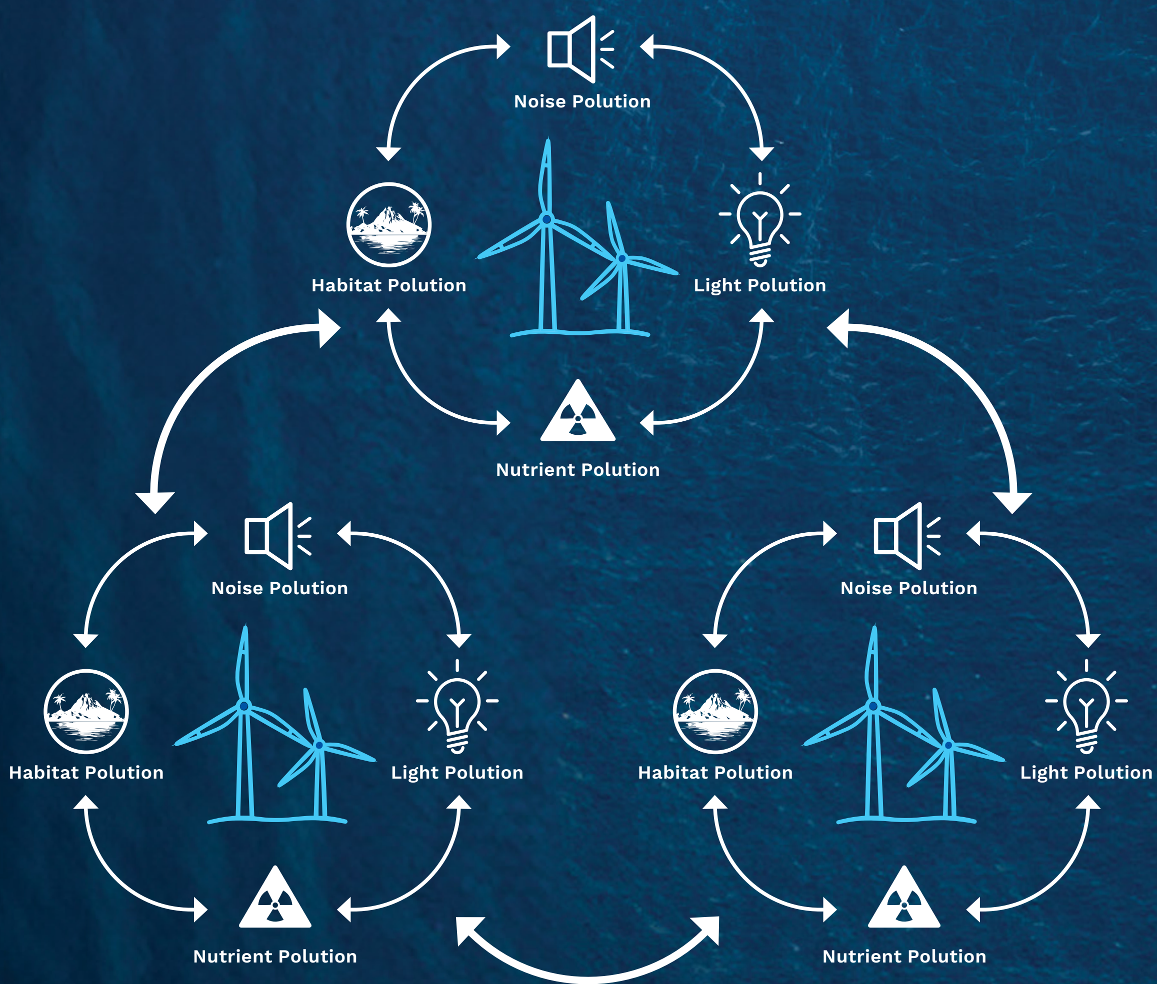


Figure 1A. Schematic of ecosystems at the core of an integrated ocean management framework. Source: Winther *et al.* (2020).

Single Project



Intra-industry



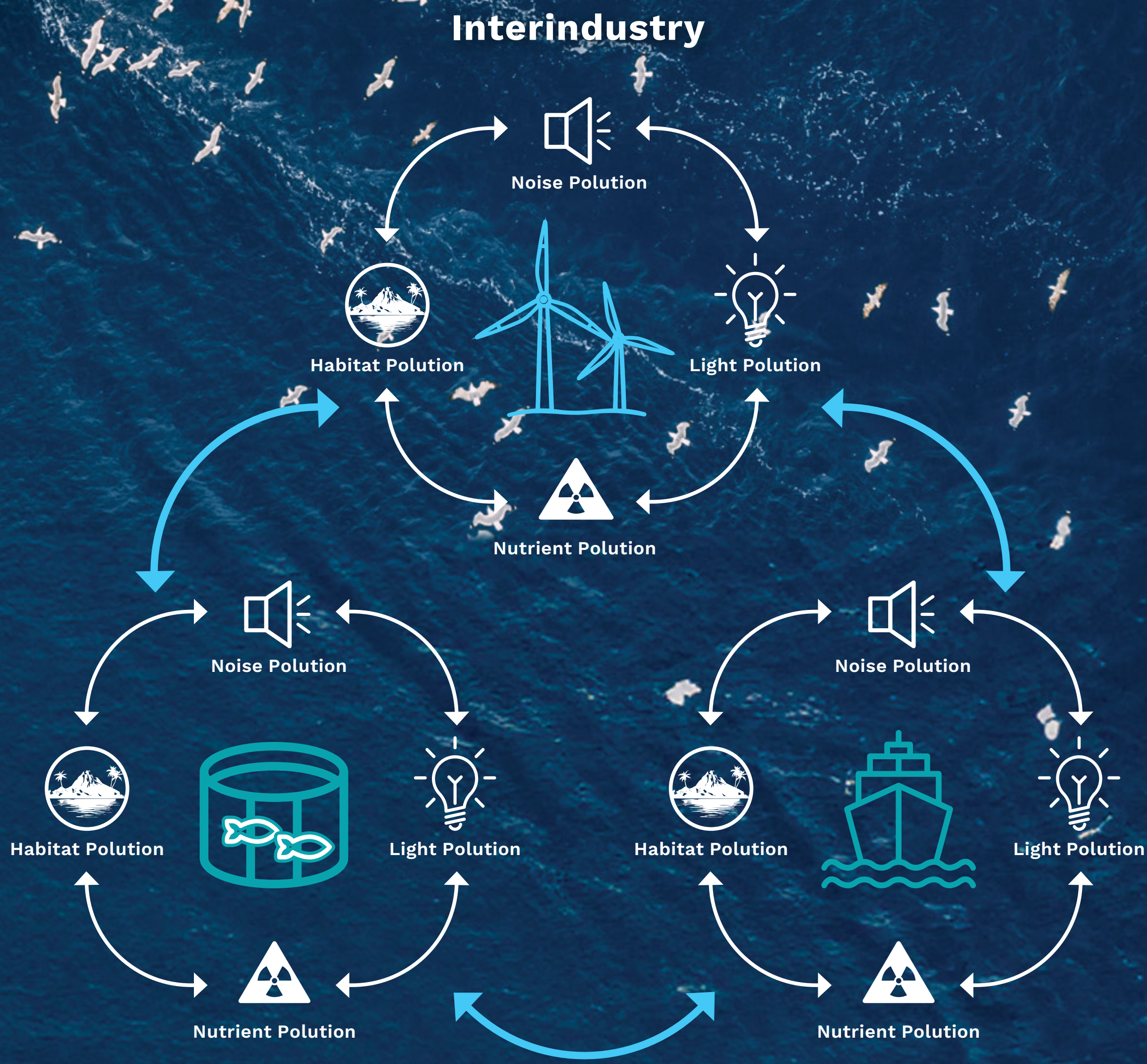


Figure 1B. Accounting for the cumulative impacts of a single project, within an industry (intra-industry), and among industries (inter-industry; Kuempel *et al.* in prep).

Integrated ocean planning and management frameworks, such as marine spatial planning, provide opportunities over sector-based frameworks including:

- **Identify synergies and trade-offs between sectors.**
- **Equitable distribution of ocean resources and space allocation among industries.**
- **Effective planning to reduce conflicts depending on the level of activity within an area.**
- **Integration of cumulative impacts across realms and jurisdictions.**
- **Address and plan for minimising environmental cumulative impacts.**

Mapping multiple sectors and their overlap enables management to plan for different conflict scenarios. For example, the impacts of industry interactions in the North Sea were classified as "manageable in time, space and overlap" or "mutual exclusion" to determine compatibility of ocean users for the area (Maes *et al.* 2005). Additionally, more efficient planning can be achieved with a greater understanding of where multiple sectors successfully co-exist.

Analysing industry interactions aids in managing trade-offs between industry activities and environmental impacts relative to management and planning objectives.

For example, the negative impacts of offshore wind farms on commercial fisheries associated with the loss of fishing grounds needs to be considered alongside the benefits to biodiversity due to the creation of artificial reefs (Halouani *et al.* 2020). Furthermore, an integrated approach can identify synergies between industry impacts, providing an opportunity for management intervention to prevent compounding environmental impacts among activities.

We show the importance of an integrated ocean management framework to Australia by reviewing the EIAs from five proposed wind farm projects for Bass Strait, a hotspot for emerging and existing Blue Economy activities in Australia.

These EIAs were completed based on sector-based management, where the proponent is required to consider only project-based impacts. The proposed size of these offshore wind projects varied significantly, ranging from 62 to 400 turbines per assessment.

We summarised and compared the number of species assessed within a project, within a single industry, and across industries (Fig. 1b). We found that the cumulative number of species assessed across all five wind farm projects was significantly higher than that of individual projects (Fig. 2a), as was the cumulative number of species assessed between multiple industries (Fig. 2b).

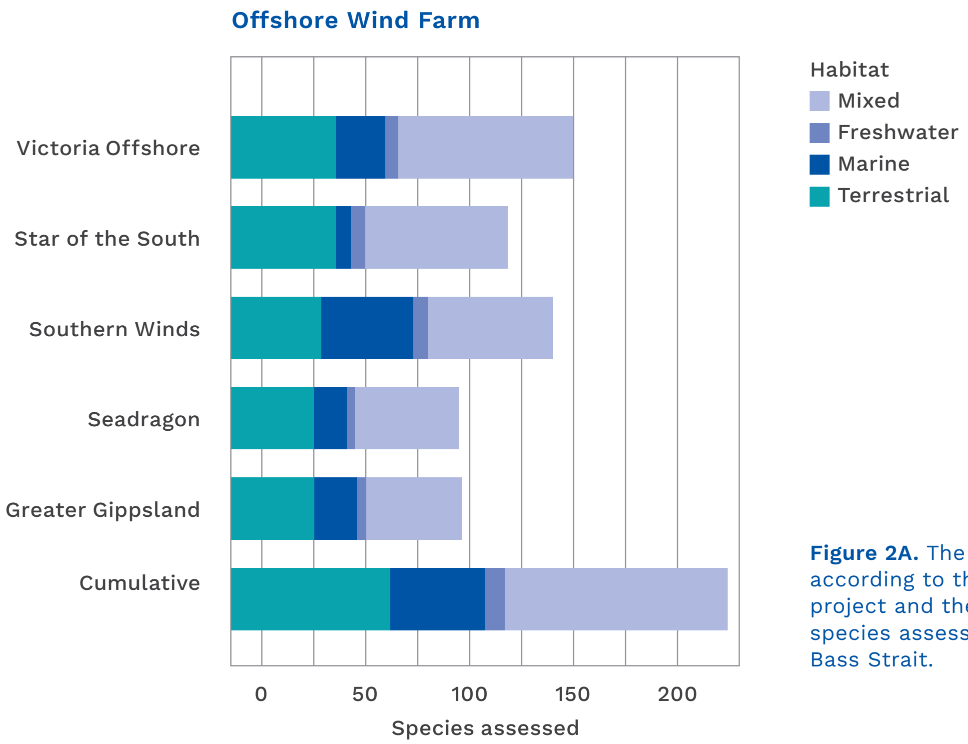


Figure 2A. The number of species assessed according to the EIA of each wind farm project and the cumulative number of species assessed across all projects within Bass Strait.

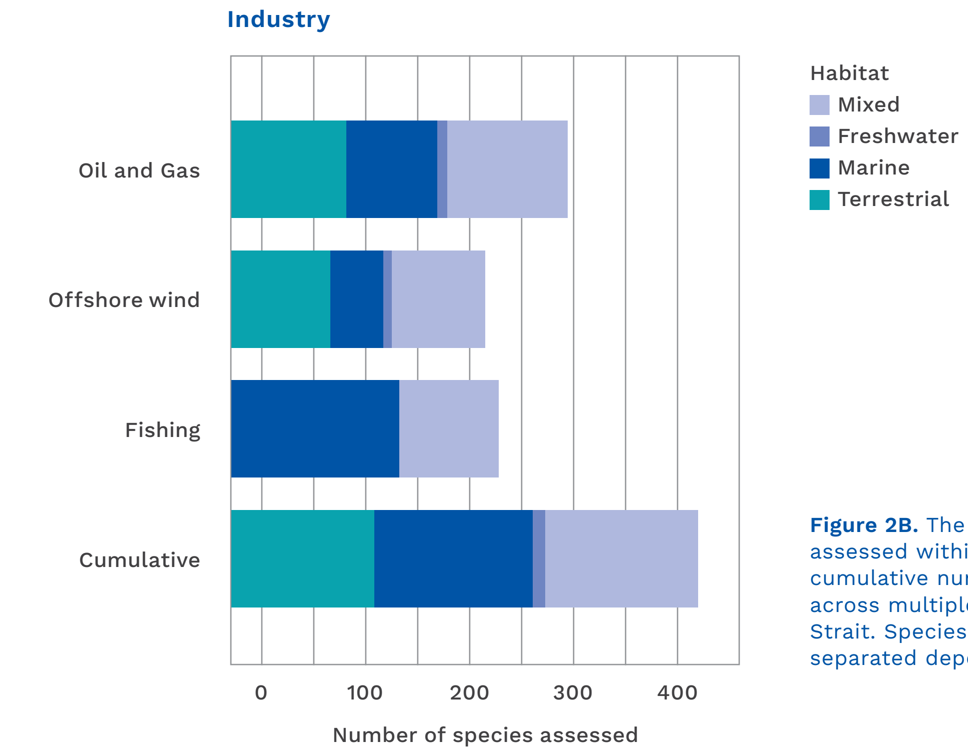


Figure 2B. The number of species assessed within each industry and the cumulative number of species assessed across multiple industries within Bass Strait. Species numbers for A) and B) are separated depending on IUCN habitat type.

Collating the data on impacted species from EIAs identifies the species that are at the greatest risk from multiple project-related impacts, both within and across industries. A total of 162 unique species appeared in two or more wind farm EIAs, and 355 across multiple industries.

For example, the curlew sandpiper (*Calidris ferrugineal*) was identified as at risk of turbine collisions across multiple wind farm EIAs, and of habitat degradation via oil pollution in an offshore oil EIA. Additionally, we emphasise the importance of transparent reporting and open-access data to make our approach applicable across multiple industries.

By incorporating this information into planning, decision-makers have a greater understanding on where industry-related impacts may interact to cause synergistic effects on the populations of species listed under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999.

Our results highlight the importance of an integrated ocean management plan for Bass Strait if Australia

Additionally, Australia would benefit from a framework that integrates across jurisdictions and realms to account for impacts that span multiple habitat types (Fig. 2).

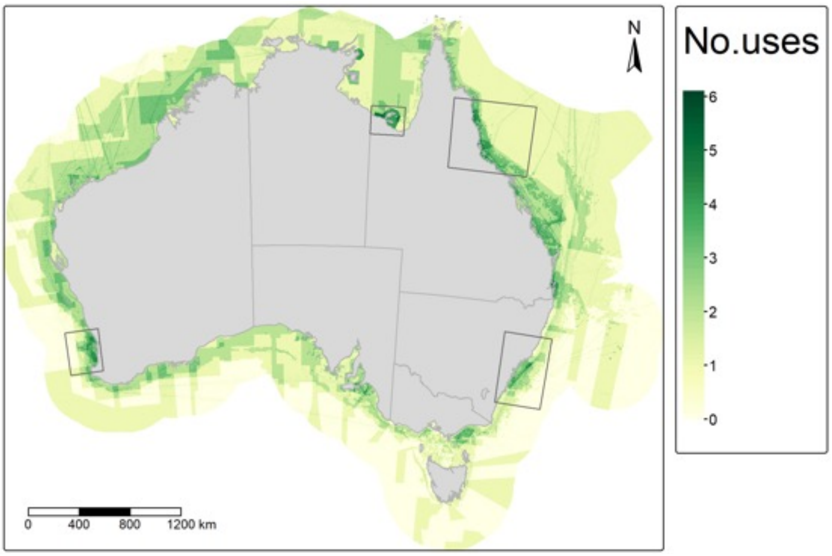
Across all EIAs, 98 different impacted species utilise both terrestrial and marine habitat, and 45 occupy terrestrial, freshwater, and marine habitats.

5. Industry overlap in Australia

To identify industry overlap within Australia's EEZ, we collated spatial data on existing ocean uses by offshore industries including aquaculture, commercial fishing, indigenous and marine protected areas (IPAs and MPAs), oil lease areas, petroleum pipelines, ports and terminals, recreational boats (including charter boats), shipping, underwater cables, and declared offshore wind farm zones (Table S1).

We identified that 30% (2,064,596 km^2) of Australia's EEZ is occupied by more than one industry (ranging from 2 to 7) on a 1 km grid (Fig. 3), underscoring the need for implementing an ocean management approach that incorporates multiple industries. There was a high number of uses around major cities, such as Perth, Sydney, and Cairns, as well in the Gulf of Carpentaria in the Northern Territory (Fig. 3).

Hotspots of high sector overlap represent areas where special consideration is needed to minimise the risk of inter-industry conflict, and opportunities to maximise any synergies.



Areas of high industry overlap are also more likely to produce synergistic environmental impacts, emphasising the need to account for industry interactions in environmental impact assessments.

Figure 3. The number of existing ocean uses in Australia including aquaculture, commercial fishing, IPAs, MPAs, oil lease areas, petroleum pipelines, ports and terminals, recreational and charter boats, shipping, underwater cables, and declared wind farms. Areas of high use are indicated.

To demonstrate how our approach could be used to inform regional planning, we collated local scale data of offshore industry uses for Bass Strait. We mapped the locations of industry use within Bass Strait (Fig. 4), then quantified the number of overlaps between each industry pairing to provide a snapshot of the frequency of industry interactions (Table 1). We found that commercial fisheries most often overlap with other industries (62,193 total occurrences; 29.9% of cells), most notably oil lease areas (23,103; 11.1%) and shipping (19,494; 9.4%).

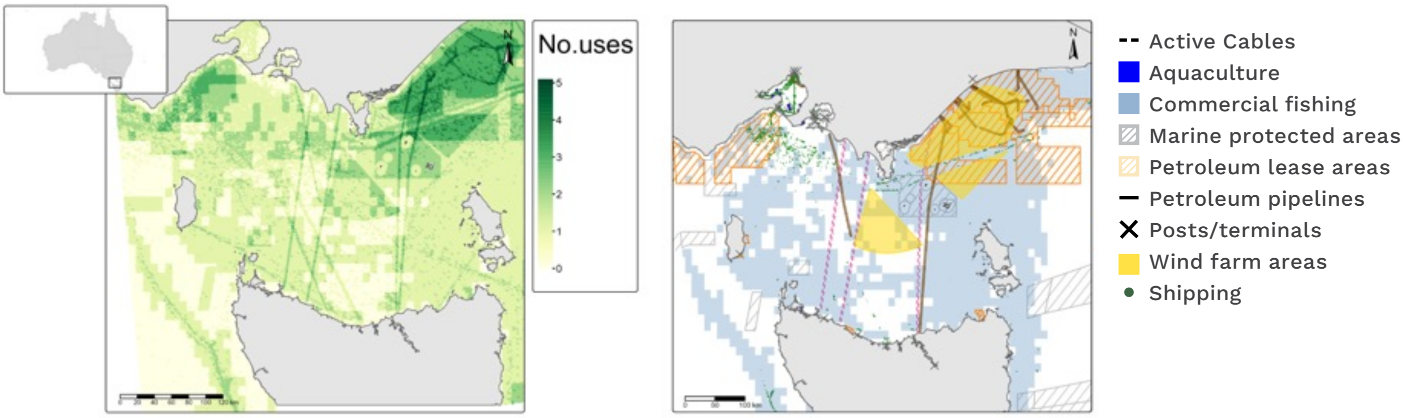


Figure 4. Industry ocean use within the Bass Strait including aquaculture, commercial fishing, IPAs, MPAs, oil lease areas, petroleum pipelines, ports and terminals, recreational and charter boats, shipping, underwater cables, and declared wind farms. Inset map shows Bass Strait location within Australia.

	Aquaculture	Commercial fishing	IPAs	MPAs	Oil lease areas	Petroleum pipelines	Ports and terminals	Shipping	Underwater cables	Wind farm areas
Aquaculture		1	0	13	0	3	0	97	0	0
Commercial fishing	1		0	4,572	23,103	1,701	0	19,494	1,043	12,279
IPAs	0	0		0	0	0	0	1	0	0
MPAs	13	4,572	0		153	108	0	1,385	106	0
Oil lease areas	0	23,103	0	153		1,275	4	8,609	84	9,570
Petroleum pipelines	3	1,701	0	108	1,275		0	501	9	863
Ports and terminals	0	0	0	0	4	0		54	0	0
Shipping	97	19,494	1	1,385	8,609	501	54		353	2,217
Underwater cables	0	1,043	0	106	84	9	0	353		106
Wind farm areas	0	12,279	0	0	9,570	863	0	2,217	106	

Table 1. Count of cells with more than one industry within Bass Strait, Australia (total cells = 432,576).

In the April 2024 milestone report, we summarised the different interactions between industries using global examples.

Here, we identified frequent overlap between existing commercial fisheries and the declared wind farm locations within Bass Strait (Fig. 4; Table 1). Careful planning of offshore wind farms is necessary to mitigate conflict between these industries and avoid disrupting the economic contributions by commercial fisheries (DAFF 2022). Offshore wind farms often operate with exclusive rights of the space they occupy (Schupp *et al.* 2021), leading to fishing bans such as those implemented in Europe (e.g., Buck *et al.* 2004; Bergman *et al.* 2015).

Though some fishing is still allowed within particular wind farm zones depending on gear type and vessel size (Bonsu et al. 2024), there are risks associated with fishing in the vicinity of an offshore wind farm. These include damage to fishing gear from snags or entanglement, and the danger to vessels and the fishers onboard (Rodmell and Johnson 2002). Furthermore, wind turbines act as artificial reefs that potentially attract commercial fish species, displacing them from nearby fishing grounds (Stenberg *et al.* 2015).

However, there is also evidence of opportunities for fisheries closely associated with wind farms. The artificial reefs can provide benefits to commercial fisheries due to spillover effects from the reefs populating fish and crustacean stocks (Stelzenmüller *et al.* 2021).

Informed planning when managing offshore industry expansion will mitigate the mounting opposition from fishers (Alexander et al. 2013; Hooper et al. 2015), which has led to increased costs to wind farm proponents via compensation to the fisheries industry (Alexander et al. 2013).

We also found common overlap between shipping and commercial fishing (Table 1). Examples from other regions have demonstrated the disruptions of these industries to one another, through damage to shipping vessels from discarding fishing gear (Hong *et al.* 2017), and tanker oil spills causing closures of fisheries (Garza-Gil *et al.* 2006).

Moreover, these industries are attributed to similar environmental impacts, including noise pollution from vessels (Hildebrand 2009), and altering nutrient cycling (Mayer *et al.* 1991; Moldanova *et al.* 2022), highlighting the potential for synergistic environmental impacts.

Planning and management should consider industry conflict and synergistic environmental impacts with the opportunities presented by identifying overlaps. Multiple industries can mutually benefit by sharing costs of labour, fuel, and infrastructure, such as existing ports and terminals (Ding et al. 2014; Klinger *et al.* 2018).

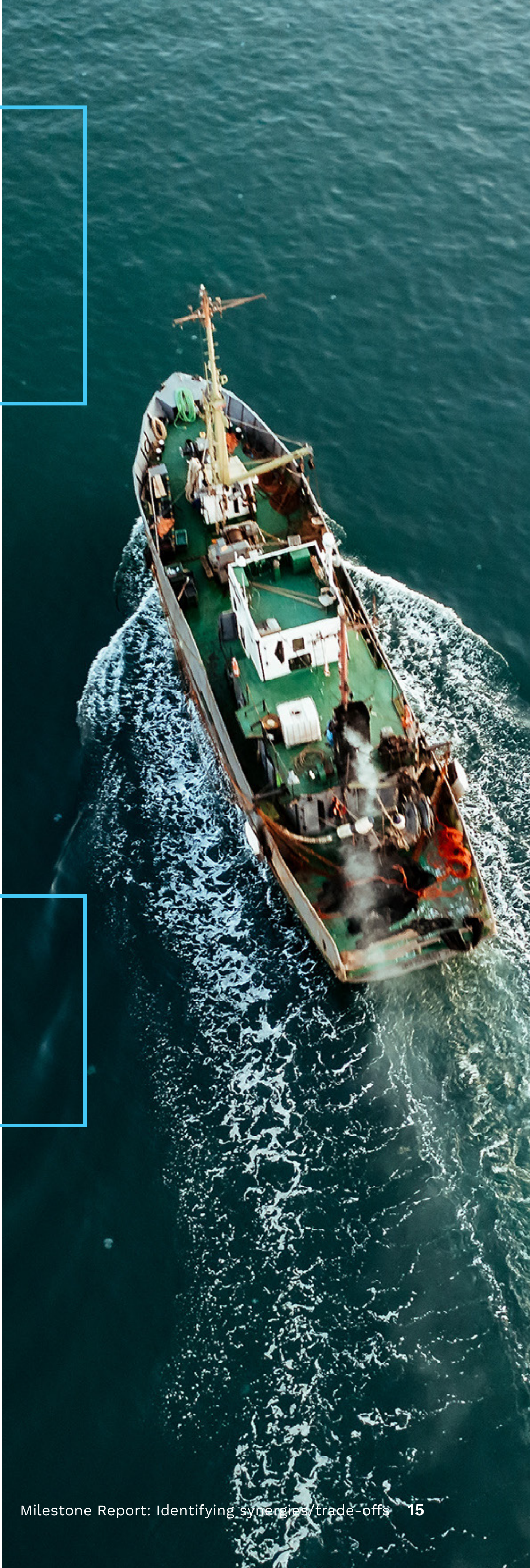
There are also situations where one industry can benefit by being closely associated with another. For example, shared transport of construction materials, personnel, and equipment is a potential benefit to multiple industries that share space with shipping (Klinger *et al.* 2018).

Commercial fishing and oil lease areas represent the most common industries to overlap in Bass Strait (Fig. 4; Table 1).

Oil rigs create artificial reefs that attract commercially important pelagic fish species and crustaceans (Macreadie et al. 2011), and oil platforms have historically been used for fishing (Ditton and Auyong 1984), showcasing potential for neutral or beneficial co-existence between multiple industries.

In addition to maximising cost-savings through industry overlap, there are alternative strategies for integrated ocean planning and management to optimise the use of ocean space when two industries mutually benefit from co-location.

In recent years, the viability of multi-use platforms has gained increased attention as a strategy to optimise efficiency in utilising ocean space (Depellegrin *et al.* 2019). Co-locating aquaculture and wind farming is often viewed as a feasible option, though further work is needed to address concerns related to liability and cost-effectiveness (van den Burg et al. 2020; Huang *et al.* 2022).



6. Opportunities for aquaculture and offshore wind co-location

We explored the co-location potential for aquaculture and wind farms in Bass Strait by combining productivity data for both industries. We used existing spatial data on wind power density (Davis et al. 2023) with fish and bivalve (from Gentry *et al.* 2017), and seaweed (Spillias *et al.* 2023) aquaculture production potential.

Wind power density (in W/m^2) represents a measure of wind energy generation per unit area. These data were constrained by ocean depth, which determines the most suitable wind farm foundation type (Dvorak *et al.* 2010), significant wave height frequency (Gintautas and Sørensen 2017), and existing ocean uses including shipping and protected areas.

We identified 6421 km^2 (4.6%) of suitable ocean space for offshore wind farm operations in Bass Strait when considering resource availability and site constraints. Our results show that no ocean space is suitable for co-location of wind and bivalve aquaculture, though this is restricted by data limitations on bivalve production potential for Bass Strait. We found high co-location potential for offshore wind and fish aquaculture in 3280.5 km^2 (2.35%) of ocean space, and 526.4 km^2 (0.38%) for seaweed (Fig. 5).

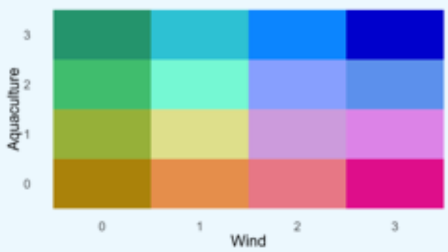


Figure 5. Co-location potential for wind farms and, (a) finfish or (b) seaweed aquaculture in Bass Strait, Australia. Values represent the bivariate correlation between aquaculture and wind power production potential. Inset map indicates Bass Strait location within Australia.

Co-location, or close association, of wind and aquaculture is possible within Bass Strait and represents a potential opportunity for efficient management of trade-offs be-tween these two industries. A multi-use platform potentially mitigates the effect of syn-ergistic impacts but opens debate on the benefits of concentrated impacts within a smaller area, or spreading impacts over a larger area where they are less likely to in-teract.

7. Future directions

The next step in creating an integrated ocean planning and management framework will involve using a DAPSIR framework (Patrício *et al.* 2016) to map cause-and-effect pathways that connect various sectors, environmental consequences, and the potential risks arising from neglecting their consideration.

Visualising the links between emerging and existing ocean users will pinpoint where it is necessary to plan for synergies and provide an overview of the trade-offs that produce the greatest benefits with minimal drawbacks.

We aim to use existing spatial data representing the industry and environmental indicators that predict financial risk of differing site selection scenarios to:

- **Quantify opportunities for minimising financial risk to industries during site selection.**
- **Evaluate the impacts on financial risk depending on different scenarios, such as maximising profit.**
- **Assess how financial risk changes as emerging offshore industries are established and displace existing users.**

8. Conclusion

The approach presented here represents an initial step in developing an integrated ocean planning and management framework that will provide a more holistic overview of potential interactions and trade-offs between sectors.

Our approach provides greater understanding of where synergistic environmental impacts are likely to occur, allowing intervention to manage unpredictable changes in ecosystem condition, as well as plan for potential conflicts and co-location opportunities between industries to inform decision making and sustainable growth of the Blue Economy.

9. Supplementary information

Table 1S. All data layers included in ocean uses analysis (Figs. 3, 4 & Table 1) and links to source.

Data	Date	Description	Format	Source
Active underwater cables	2021	Australia's submarine telecommunication cable locations. Data include a 1 km buffer to account for an activity prohibited area to protect cables from damage.	Line	https://geoscience-au.maps.arcgis.com/home/item.html?id=bc1e7fb37fca40faa5dafbc8a5a4dc3c
Aquaculture	2019-2023	Aquaculture operations and facilities.	Point/ Polygon	**QLD:** https://qldglobe.information.qld.gov.au/ **NSW:** https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal **SA:** https://data.sa.gov.au/data/dataset/aquaculture-leases-and-licences **WA:** https://catalogue.data.wa.gov.au/dataset/aquaculture-sites-dpird-001 **TAS:** https://www.thelist.tas.gov.au/app/content/data/geo-meta-datarecord?detailRecordUID=10db46db-698d-43e6-a1a7-e1bfff13aedc **NT:** Not included, not publicly available **VIC:** https://mapshare.vic.gov.au/coastkit/

Data	Date	Description	Format	Source
Commercial fishing	2014-2017	Average fishing effort within licensed grids based on vessel logbook data for the most recent year available. **Fisheries:** Δ Bait net Δ Coastal line Δ Coastal net Δ Gillnet Δ Handline Δ Haul net Δ Jig Δ Longline (auto, demersal and pelagic) Δ Offshore net and line Δ Pole Δ Restricted bait Δ Seine net (Danish and purse) Δ Trap and pot Δ Trawl Δ Trotline Δ Troll Species-specific fisheries (additional species may be covered by more general fisheries): Δ Abalone **QLD:** Lease numbers provided by the Department of Fisheries, which were cross referenced with lots number on QGlobe.	Polygon	https://marlin.csiro.au/geonet-work/srv/eng/catalog.search#/metadata/aa53a4df-7fe6-46d1-93b7-2d3732f4883e **NT:** https://data.gov.au/dataset/ds-marlin-262fec77-f800-4d69-adf1-a572c829234e/details?q= **SA:** https://data.gov.au/dataset/ds-marlin-be790a20-eed5-4570-85dc-dd548ce606d6/details?q=fishing%20effort%20maps%20south%20australia **QLD:** https://data.gov.au/dataset/ds-marlin-ac413df7-19ed-475c-b121-9aeec44b6cf0/details?q=fish-ing%20effort%20maps%20queensland
Indigenous Protected Ar-eas	2023	Dedicated through the implementation of the Indigenous Protected Areas programme.	Polygon	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BC64658F0-95AD-4209-8D1E-F94BD0A4E827%7D
Marine Pro-tected Areas	2022	Collaborative Australian protected areas database (CAPAD).	Polygon	https://www.dcceew.gov.au/environment/land/nrs/science/capad

Data	Date	Description	Format	Source
Oil lease areas	2016	Titles, tenements and leases established for exploration and/or production purposes.	Polygon	https://catalogue.aodn.org.au/geonetwork/srv/eng/catalog.search#/metadata/836b1a1d-19d8-4f66-b12f-88e4ce9ba19c?uuid=836b1a1d-19d8-4f66-b12f-88e4ce9ba19c
Petroleum pipelines	2017	Active and decommissioned sub-marine petroleum pipelines.	Line	https://catalogue.aodn.org.au/geonetwork/srv/eng/catalog.search#/metadata/19d8f59a-b918-442f-8e2c-d80125600868?uuid=19d8f59a-b918-442f-8e2c-d80125600868
Ports and terminals	2016	Locations of ports and public ferry terminals.	Point	https://geoscience-au.maps.arcgis.com/home/item.html?id=37645b11e26d4394a6489865e49e0d9b
Recreation	2015	Number of km's recorded in vessel logs by recreational boat users. Hotspots of activity were determined using the 95th percentile of the raw data.	Polygon	https://marlin.csiro.au/geonetwork/srv/eng/catalog.search#/metadata/b8135966-33c6-4a1c-bcbc-d797c2a1155f
Recreation	2016	Placement of fish aggregating devices.	Point	https://data.imas.utas.edu.au/static/landing.html
Shipping	2023	Vessel traffic from Automatic Iden-tification System (AIS) data sources for August 2023.	Point	https://www.operations.amsa.gov.au/Spatial/DataServices/DigitalData
Declared wind farm areas	2021-2023	Areas declared suitable for offshore wind farms.	Polygon	https://geoscience-au.maps.arcgis.com/apps/webappviewer/index.html?id=ad633ccdcfe94469879bf479a1df1886

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PO Box 897, Launceston, Tasmania 7250

www.blueeconomycrc.com.au

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